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METHODS OF DETERMINING THE DATE OF  
ROMAN CONCRETE MONUMENTS

(SECOND PAPER)

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V. THE PERIOD OF THE INTRODUCTION OF ROOF-TILE  
FACING (AUGUSTUS-CLAUDIUS)

*Augustus.* — The plans of Julius Caesar for his new capital, interrupted by his untimely death, were accepted by his successor and heir as a part of his inheritance. Augustus, however, cast in a different mould from his adopted father, gave to these plans and to the public monuments in which they were embodied a character wholly their own. This distinctive character manifests itself, in the existing monuments, not only in certain new architectural and decorative forms, but also in a new and independent type of construction, to the introduction of which is due, in large part, the importance of the age in the history of the art of building.

The new type of construction, arising in part from the abandonment of much which was faulty in the earlier type, owing to its transitional character, is especially worthy of note in the following respects:

(1) The clearer recognition of the values of the various materials and methods of construction.<sup>1</sup>

(2) The consequent elimination of many which were inadequate or worthless.

(3) The introduction of certain new materials and methods, as well as of a number of new principles.

(4) A distinct advance in technique, due possibly to the importation, in larger numbers, of foreign workmen as well as of foreign ideas.

<sup>1</sup> Concerning the value of the various materials and methods, see the second book of the *De Architectura* of Vitruvius.

(5) The appearance, especially in public monuments, of a recognized, though imperfect, canon of construction.<sup>1</sup>

The most conspicuous results of this general advance in the art of construction were the abandonment of sun-dried bricks, or *lateres*, as a building material,<sup>2</sup> and the marked increase in the use of *opus caementicium*, with its variant, *structura testacea*, for all classes of monuments. With the clearer understanding of the comparative value of the different materials, also, the more friable tufas were abandoned, except for vaults, and a firmer reddish brown variety was adopted almost universally both for walls of *opus quadratum* and for the *caementa* in structures of *opus caementicium*. In place, too, of the earthy *pozzolana-arena* of the earlier periods, a clean red variety<sup>3</sup> was introduced, to the use of which is due, in large part, the strength of the Roman concrete. To the group of structural materials were added, also, broken roof-tiles, or *tegulae*.<sup>4</sup> These tiles were used alike for *caementa* and facing in the new type of construction, called by Vitruvius<sup>5</sup> *structura testacea*, out of which, when combined as a facing with the earlier *opus caementicium*, was developed at a later time brick-faced concrete, the typical Roman construction.<sup>6</sup> As a decorative material, Luna marble was introduced, the extensive use of which led to the boast of Augustus that he had received a city of sun-dried bricks but had left in its place one of marble.<sup>7</sup>

<sup>1</sup> The endeavor to create such a canon is shown in the establishment by Augustus of certain general building regulations (Vitr. *De Architectura*, II, VIII, 17; Suet. *Aug.* 89). A considerable portion of the valuable, though pedantic, treatise of Vitruvius is clearly designed, also, to further this endeavor.

<sup>2</sup> It is possible that the regulation by law of the width of walls (Vitr. *l. c.*; Suet. *l. c.*) was designed in part to attain this end, since walls of sun-dried bricks (*structura latericia*) were, of necessity, thicker than those made of other materials. It is clear from the words of Vitruvius, as well as from other evidence, that sun-dried bricks were still in common use in the time of Augustus.

<sup>3</sup> This *pozzolana-arena*, the *arena rubra* of Vitruvius (*l. c.* II, IV, 1), which is that now found, according to Brocchi (*Del Suolo Fisico di Roma*, p. 117), near the Tre Fontane, is still regarded as the best variety near Rome.

<sup>4</sup> Vitr. II, VIII, 19, *et passim*.

<sup>5</sup> Vitr. II, VIII, 17, 18, 19.

<sup>6</sup> Nissen holds (*Pomp. Stud.* p. 4) that the most distinctive characteristic of Roman construction throughout the empire is the preference shown in it for the use of bricks and *pozzolana* mortar.

<sup>7</sup> Suet. *Aug.* 28: *Urbem . . . excoluit adeo ut iure sit gloriatus mar-moream se relinquere quam latericiam accepisset. Latericius*, as well as *later*

In methods of construction, also, an advance is noticeable, in monuments both of *opus quadratum* and of *opus caementicium*, in the adaptation of the materials to the structural demands of the various monuments or parts of monuments in which they are used.<sup>1</sup> For ordinary walls of *opus quadratum*, reddish brown tufa was commonly employed. Peperino, however, on account of its fireproof qualities,<sup>2</sup> was substituted for it in certain buildings or parts of buildings, while travertine was used for points of special pressure as well as for decorative purposes. The earlier grayish yellow tufa was retained, on account of its light weight, for the *caementa* of vaults.

By reason of the fuller recognition, at this time, of the special fitness of *opus caementicium* for the more massive parts of structures, such as foundations and podia, important monuments made wholly of *opus quadratum* are very rare.<sup>3</sup> The materials used in those of which remains are left are reddish brown tufa, peperino, travertine, and marble. The monuments which may be assigned, though only tentatively,<sup>4</sup> to this class are the following<sup>5</sup>: the porticus of Octavia (*ca.* 23 B.C.),<sup>6</sup> the arch of Dolabella (10 B.C.), the ara Pacis (9 B.C.), the aqueduct arch inside the porta Tiburtina (5-4 B.C.), the forum of Augustus and the temple of Mars Ultor (6-2 B.C.). The Marmorata in the Campus Martius and the embankments of the Tiber were probably wholly of *opus quadratum*, as they are reported to have been.

when used alone, refers always to sun-dried bricks. The use of kiln-dried bricks as material for walls was first introduced, as has been said, by Augustus himself.

<sup>1</sup> Cf., for example, Vitr. *l.c.* II, IV, 3; II, V, 1; II, VI, 6.

<sup>2</sup> In the history of Roman construction as well as in the topography of the city, the influence of the various fires has not been properly estimated. For a list of the fires during the imperial period, see P. Werner, *De Incendiis Urbis Romae Aetate Imperatorum*, Leipzig, 1906.

<sup>3</sup> Its use was, however, apparently commended by Augustus (Plut. *Apophthegm.* Aug. 15).

<sup>4</sup> No final classification of these monuments is at present possible, since the data concerning the material used in the foundations are incomplete.

<sup>5</sup> Owing to the nature of the discussion, the list here given, as well as those which follow, includes only the monuments to which a date is assignable on other grounds than those of construction. Certain of the other monuments will be discussed in following papers.

<sup>6</sup> The brick-faced walls of the porticus belong to a later restoration.

The larger number of monuments,<sup>1</sup> however, while retaining *opus quadratum*<sup>2</sup> for the greater part, at least, of the superstructure and external walls, adopted even more generally than in the last period *opus caementicium* for the foundations and the other more massive portions of the structure. The materials used for the *opus quadratum* in this class of monuments were the same as those used in the preceding class.

The monuments built wholly of *opus caementicium* were, with a few notable exceptions,<sup>3</sup> of secondary importance, consisting chiefly of private houses or structures of small size. These monuments, so far as they are at present determined, are the following:

The altar base in front of the temple of Julius Caesar (43 B.C.).

The "schola kalatorum" (ca. 36 B.C.).

The aqua Julia (?) (33 B.C.).<sup>4</sup>

The mausoleum of Augustus (28 B.C.).

The columbarium of the freedmen of L. Arruntius (ca. 6 B.C.).<sup>5</sup>

The fountain and aedicula<sup>6</sup> of Juturna (ca. 6 A.D.).

The aqua Alsietina (10 A.D.).<sup>7</sup>

The columbarium of the slaves and freedmen of Marcella.<sup>8</sup>

The "auditorium of Maecenas."

The house of Livia on the Palatine: the upper walls.

The villa of Livia at Prima Porta.

The columbarium of the freedmen of Livia.<sup>9</sup>

With the introduction of broken roof-tiles as a material for walls arose, as has been said,<sup>10</sup> the special form of concrete construction called *structura testacea*.<sup>11</sup> This differs from *opus*

<sup>1</sup> The list of these monuments is the same as that given on pp. 392 ff., with the exception of those given immediately below.

<sup>2</sup> *Opus quadratum* was probably retained, in certain cases, with a view to economy of space.

<sup>3</sup> The mausoleum of Augustus, the aqua Julia (?), and the aqua Alsietina (?).

<sup>4</sup> Lanciani, *Acque*, pp. 92-93.

<sup>5</sup> Piranesi, *Antichità di Roma*, II, pls. IX, X, XVI.

<sup>6</sup> Boni, *Not. Scav.* 1901, pp. 71, 84.

<sup>7</sup> Nibby, *Dintorni di Roma*, I, 134; Hülsen-Jordan, *Top.* p. 654, n. 83.

<sup>8</sup> Mau, 'Rostra Caesaris,' *Röm. Mitt.* XX, p. 260. <sup>9</sup> Mau, *l.c.* <sup>10</sup> P. 388.

<sup>11</sup> Vitruv. *l.c.* II, VIII, 19, *quare maxime ex veteribus tegulis testa structi parietes firmitatem poterunt habere.*

*caementicium* faced with *opus testaceum*, the common Roman construction, only in the restriction of the material used for the *caementa* of the structure to roof-tiles.<sup>1</sup>

The number of the monuments in which the new type of construction appears is very small, but five having as yet been found.<sup>2</sup>

The *opus caementicium* of the period, whether used alone or with *opus quadratum*, is very uniform in type. The *caementa*, except in the five monuments mentioned below, consist almost entirely, both in foundations and in walls, of reddish brown tufa, the typical material of the period, with, at times, a small amount of the grayish yellow or lighter brown tufa of the earlier periods. *Cappellaccio*, travertine, and peperino are, also, occasionally found, but no *selce* and, practically, no bricks or marble. In the foundations and podia, the *caementa* are large and are laid with little attention to order; in the walls, however, they rarely exceed medium size and are arranged in somewhat irregular rows. In three of the five monuments referred to above, the Regia, and the temples of Saturn and Concord, the choice of the materials used for the *caementa* is clearly due to the large quantities of *cappellaccio* and other poorer varieties of tufa made available by the destruction of the earlier monuments to which they had belonged. The pieces of grayish yellow tufa and travertine which are used as *caementa* in the foundation walls of *opus caementicium* of the basilica Julia are plainly the refuse materials from other parts of the building. The *selce* used in the tomb of Caecilia Metella is the local stone. In the few vaults which are preserved, the *caementa* are made almost entirely of grayish yellow tufa.<sup>3</sup> The mortar is, without exception, of the dusky red type found only in this general period.<sup>4</sup> It is far finer in quality and less friable than the mortar of the republican period, though lacking the rock-like hardness of that of a century later. The *arena* consists of red or reddish brown *pozzolana*, with which a little gray and

<sup>1</sup> Though these walls are not brick walls in the modern sense of the term, they resemble them much more nearly than do those of *opus caementicium*.

<sup>2</sup> For the list of these monuments, see p. 396.

<sup>3</sup> On account of its lightness, this grayish yellow tufa continued to be used for vaults until the time of Septimius Severus.

<sup>4</sup> The general period includes also the reigns of Tiberius and Caligula.

white are occasionally mixed. This *pozzolana-arena*, though not strictly *terrosa*,<sup>1</sup> is less clean than that used at a later period, owing to the presence of a fine red dust, to which is due the dusky red color of the mortar.<sup>2</sup> The lime is more abundant than in the republican mortar<sup>3</sup> and is of a very good quality. Thin layers of tufa, travertine, or marble chips<sup>4</sup> appear at somewhat regular intervals in the body of the concrete, pointing clearly to the width of the portions of the structure made at one time.

In the limited number of buildings or separate walls where a facing was required, *opus reticulatum*<sup>5</sup> was used.<sup>6</sup> *Opus incertum* was still retained, however, in a few monuments outside of Rome.<sup>7</sup> The *tesserae* of the *opus reticulatum* are made normally of reddish brown tufa<sup>8</sup> and measure from 6 cm. to 10 cm. across the face.

The principal monuments or parts of monuments belonging to the age of Augustus in which *opus caementicium* was used are the following:<sup>9</sup>

The altar base in front of the temple of Julius Caesar (43 B.C.).

The temple of Julius Caesar: the foundations and the podium (42-29 B.C.).

The temple of Saturn: the foundations and the podium (42 B.C.).

The Regia: the upper part of the foundation walls (36 B.C.).

The "schola kalatorum" (ca. 36 B.C.).

The aqua Julia (?) (33 B.C.).

<sup>1</sup> For the meaning of this term, see Vitruvius, *l.c.* II, IV, 1.

<sup>2</sup> Cf. the mortar of the time of Trajan and Hadrian, pp. 415, 418.

<sup>3</sup> For the proportions of the lime and *pozzolana*, see Vitruvius, *l.c.* II, V, 1.

<sup>4</sup> The *caementa marmorea* of Vitruvius (*l.c.* VII, VI, 1).

<sup>5</sup> *Opus reticulatum* was correctly held by Mau (*l.c.* pp. 260 f.) to be the typical facing of the Augustan age.

<sup>6</sup> The more important monuments in which *opus reticulatum* appears are: the "schola kalatorum," the aqua Julia (?), the mausoleum of Augustus, the theatre of Marcellus, the domus Publica, the fountain of Juturna, the aqua Alsietina (?), the columbarium of the freedmen of Marcella, the "auditorium of Maecenas," the house of Livia on the Palatine, and the villa of Livia at Prima Porta.

<sup>7</sup> The most noted example is the Pondel at Aosta.

<sup>8</sup> In a few cases, other varieties of tufa are used.

<sup>9</sup> For the class of monuments included in this list, see p. 389, n. 5.

The curia Julia: the upper part of the foundation of the steps<sup>1</sup> (29 B.C.).

The cloaca in front of the curia Julia: the vault<sup>2</sup> (29 B.C. ?).

The mausoleum of Augustus (28 B.C.).

The Rostra Augusti: the hemicycle and the foundations of the rectangular structure (20 B.C. ?).<sup>3</sup>

The arch of Augustus: the foundations (19 B.C.).

The theatre of Marcellus: the foundations and the inner walls (13 B.C.).

The pyramid of Cestius: the foundations and the body of the structure<sup>4</sup> (before 12 B.C.).

The temple of Vesta: the foundations and the podium (14–12 B.C.).

The domus Publica: the walls faced with *opus reticulatum* and the foundations of the walls of *structura testacea* (14–12 B.C.).

The basilica Aemilia: the foundations of the steps on the north (?) and the foundation wall of the columns (14–2 B.C.).

The large cloaca under the basilica Aemilia: parts of the top and of the walls (14–2 B.C.).

The sacellum Cloacinae: the upper part (14–2 B.C.).

The porticus of Lucius and Gaius<sup>5</sup> and the tabernae novae: the foundations of the porticus and of the tabernae (2 B.C.).

The temple of Magna Mater on the Palatine (?) (3 A.D.).

The temple of Castor: parts of the foundation and of the podium<sup>6</sup> (6 A.D.).

The fountain and aedicula<sup>7</sup> (?) of Juturna (*ca.* 6 A.D.).

The aqua Alsietina (10 A.D.).<sup>8</sup>

<sup>1</sup> For the lower part of the foundations of the steps, see the previous paper, p. 251.

<sup>2</sup> Hülsen, *Röm. Mitt.* XVII, p. 37, fig. 9.

<sup>3</sup> See Van Deman, *The So-called Flavian Rostra*, *A.J.A.* XIII, pp. 175–176, 180–181.

<sup>4</sup> Nibby, *R.A.* II, pp. 534 ff.; Piranesi, *Ant. di Roma*, III, pl. XL–XLVIII.

<sup>5</sup> The evidence for the identification of the colonnade in front of the basilica Aemilia with the porticus of Lucius and Gaius will be presented in a later article.

<sup>6</sup> The greater part of the existing remains is of the time of Augustus. There are no traces of a restoration by Hadrian.

<sup>7</sup> See above, p. 390, n. 6.

<sup>8</sup> For references, see p. 390, n. 7.



The temple of Concord: the foundation of the steps and parts of the podium (10 A.D.).

The columbarium of the slaves and freedmen of Marcella (*ca.* 10 A.D.).<sup>1</sup>

The basilica Julia: the foundation of the steps and the foundation wall of the columns (12 A.D.).

The shops adjoining the basilica Julia: the foundations (?) and the vaults (*ca.* 12 A.D.).

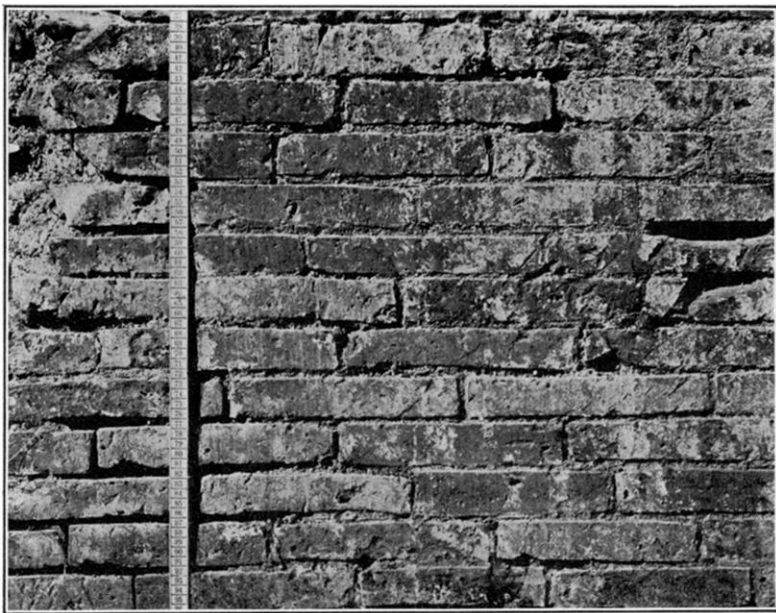


FIGURE 1. — BRICK FACING OF THE TIME OF AUGUSTUS.<sup>3</sup>

The so-called Cloaca Maxima: parts of the roof and walls.<sup>2</sup>  
The *cuniculi* (completed or restored by Augustus).

The “auditorium of Maecenas.”

The tomb of Eurysaces: the foundations (?) and the body of the structure.

The tomb of Lucilius Paetus: the foundations (?) and the body of the structure.

<sup>1</sup> Mau, *Röm. Mitt.* XX, p. 260.      <sup>2</sup> Narducci, *Fognatura di Roma*, p. 41.

<sup>3</sup> From the Rostra Augusti. The photographs used in this and in the illustrations which follow, except in Figure 4, were taken at the distance of a meter and a half from the walls.

The tomb of Caecilia Metella: the foundations and the body of the structure.

The house of Livia on the Palatine: the upper walls.

The villa of Livia at Prima Porta.

In the walls<sup>1</sup> made of *structura testacea*, the *caementa* consist wholly, as has been said,<sup>2</sup> of the same broken roof-tiles which are used for the facing. The pieces are large and are laid, as a rule, in closely packed though somewhat irregular courses. The mortar is the same as that of the *opus caementicium* described above.

The facing is composed entirely of bricks made from roof-tiles, or *tegulae* (Fig. 1). These tile bricks are, as a rule, irregularly trapezoidal in shape, showing no tendency, as at a later time, to approach the triangular form. The fronts are evenly sawed;<sup>3</sup> the other sides are, however, roughly broken. Owing to the nature of the material,<sup>4</sup> the bricks differ greatly in width, varying, in the Rostra Augusti and the domus Publica, from 3.5 cm. to 4.5 cm. The average width of 50,<sup>5</sup> which may be accepted as fairly representative,<sup>6</sup> is 4.1 cm. and the mean deviation .26 cm. Between the two ends of the same brick, also, a considerable difference in width is often found. The length of the bricks varies normally from 20 to 35 cm. They are well puddled and carefully fired, being conspicuous for their almost flint-like hardness. Their color varies from a dark to a light magenta red,<sup>7</sup> with a tendency, at times, to a magenta yellow.

<sup>1</sup> The foundations of the walls of *structura testacea* are always of *opus caementicium*.

<sup>2</sup> P. 390.

<sup>3</sup> The use of the saw in the preparation of facing bricks is even more noticeable at Pompeii than in Rome.

<sup>4</sup> The *tegulae* of which the bricks are made are usually 1-2 cm. thicker at the bottom than at the top.

<sup>5</sup> The exact width of the bricks is as follows:

Measurement in centimetres.	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
Number of bricks.	3	1	2	5	0	12	5	6	4	2	1	6	2	1

<sup>6</sup> The bricks are measured, in all cases, in representative groups of 5 or 10, which are selected from as many structures, or parts of a single structure, as is possible.

<sup>7</sup> For this color, see the previous paper, p. 236, n. 4.

The mortar is slightly finer than in the body of the structure. The horizontal joints are close, varying in the Rostra Augusti from .5 cm. to 1 cm.; they are, however, somewhat wider in the domus Publica, often exceeding 1.5 cm. They are always, so far as can be determined, carefully raked.<sup>1</sup> The vertical joints are very fine, averaging little more than .6-.7 cm. No bonding courses are found.

The monuments built partially of *structura testacea*, with the specific parts of each in which it is used, are the following:

The Rostra Augusti: the walls inside of the rectangular structure and beside the steps in the rear (20 B.C.?).<sup>2</sup>

The tomb of Sulpicius Platorinus: the inner walls (18 B.C.).<sup>3</sup>

The domus Publica: fragmentary walls under the shops and street north of the atrium Vestae (14-12 B.C.).

The tomb of Cestius: the walls of the inner chamber<sup>4</sup> (before 12 B.C.).

The tomb of Caecilia Metella: the walls of the corridor and of the inner chamber.<sup>5</sup>

The principal characteristics, or "earmarks," by which the monuments of *opus caementicium* of the time of Augustus may be most easily distinguished are: (1) the dusky red color of the mortar,<sup>6</sup> and (2) the regular use of reddish brown tufa for the *caementa* both of foundations and of walls, to the exclusion of the earlier varieties of tufa as well as of bricks and marble. The walls of *structura testacea* of the same time, which are recognizable, likewise, by the color of the mortar, are still more easily distinguished by the exclusive use of broken roof-tiles for the *caementa*, as well as for the facing, of the structure.<sup>7</sup>

*Tiberius*. — The exuberant building activity of the age of Augustus was followed by a quarter of a century of inactivity.

<sup>1</sup> This fact is of especial importance in its bearing on the question of the methods employed in building brick-faced concrete walls.

<sup>2</sup> See Van Deman, 'The So-called Flavian Rostra,' *A.J.A.* XIII, pp. 175-176, 180-181.

<sup>3</sup> Platner, *Top.* (1911), p. 516.

<sup>4</sup> Nibby, *R.A.* II, p. 534.

<sup>5</sup> The data for the tomb of Caecilia Metella are not complete.

<sup>6</sup> This characteristic is, however, common to the *opus caementicium* of the whole general period, being found also in the monuments of Tiberius and Caligula.

<sup>7</sup> See n. 6.

For though Tiberius had had no small share in the great undertakings carried out by his predecessor, the ancient writers give him credit as ruling emperor for but two public works, the erection of the temple of Augustus and the restoration of the stage of the theatre of Pompey.<sup>1</sup> At least three other monuments of a more private character were, however, built by him, the castra Praetoria, the domus Tiberiana on the Palatine and the watch-tower at Capri.<sup>2</sup> Of these three monuments, as well as of a number of others built during his reign, considerable remains are preserved.

To the history of the development of Roman construction, the long years of Tiberius' reign contribute little, though a slight increase is noticeable in the importance attached to the use of *opus caementicium*.

No certain examples of monuments built entirely of *opus quadratum* remain, and but two of *opus quadratum* combined with *opus caementicium*. The other existing monuments are wholly of *opus caementicium* and *structura testacea*.

The *opus caementicium* used in these monuments differs but little from that of the time of Augustus. The *caementa* in the foundations are in part of reddish brown tufa and in part of *selce*. They are usually of moderate size and are laid with no attention to order. In the walls the *caementa* are, as a rule, largely of tufa, with a little peperino and travertine; no bricks or marble are found. In the schola Xanthi, however, *selce* is used in the walls, which are unfaced, as well as in the foundations.<sup>3</sup> The mortar is the same as that used in the Augustan monuments, except in the castra Praetoria, where a dark gray variety appears.

For the buildings or individual walls where a facing was required, *opus reticulatum* was used.<sup>4</sup>

<sup>1</sup> Tac. *Ann.* VI, 45: *ne publice quidem nisi duo opera struxit, templum Augusto et scaenam Pompeiani theatri*. Cf. Suet. *Tib.* 47; Cass. Dio, LVII, 10, 2.

<sup>2</sup> The period of the so-called palace of Tiberius is uncertain.

<sup>3</sup> The walls of the schola Xanthi, the level of which was a half metre below that of the Forum, were probably designed merely as substructures to support a platform above, on which stood some important monument, possibly the Golden Milestone.

<sup>4</sup> The principal monuments in which *opus reticulatum* is found are: The castra Praetoria: part of the wall and the inner rooms (Nibby, *l.c.* I, p. 582); the domus Tiberiana; the tomb in the Vigna Codini (Mau, *l.c.*).

The monuments or parts of monuments in which *opus caementicium* appears are the following :

The schola Xanthi (14-16 A.D.).

The arch of Tiberius in the Forum: the foundations (16 A.D.).

The castra Praetoria: the foundations and a part of the outer wall, and the inner rooms<sup>1</sup> (21 A.D.).

The columbarium of the freedmen of L. Arruntius.<sup>2</sup>

The domus Tiberiana on the Palatine: probable remains above the clivus Victoriae.

A tomb in the Vigna Codini.<sup>3</sup>

*Structura testacea* is found in two only of the more important monuments of the time in Rome,<sup>4</sup> the castra Praetoria and the tomb of Pomponius Hylas, in the former of which it is used for the outer portion only of the heavier wall of *opus caementicium*.<sup>5</sup> In general type, it shows no marked change from that of the time of Augustus. The *caementa* in the walls<sup>6</sup> are, as earlier, of broken roof-tiles laid in irregular rows. The mortar in the tomb of Pomponius Hylas is of the earlier type; in the Praetorian camp, however, it is of the dark gray variety found in the parts of the structure made of *opus caementicium*.

The facing is wholly of bricks made from roof-tiles, which in type resemble very closely those of the time of Augustus. No noticeable change appears in their width, which varies from 3.5 cm. to 4.5 cm. The average width of 50<sup>7</sup> from the Praetorian camp, which may be accepted as typical,<sup>8</sup> is 4 cm. and

<sup>1</sup> Nibby, *l.c.* I, p. 582.

<sup>2</sup> *Ibid.* II, p. 518.

<sup>3</sup> Mau, *l.c.*

<sup>4</sup> It is used also in the watch tower at Capri.

<sup>5</sup> The projecting towers, of which there were twelve, in addition to those beside the gates, are made wholly of *structura testacea*.

<sup>6</sup> The foundations of the castra Praetoria are of *opus caementicium*. Those of the tomb of Pomponius Hylas are not visible.

<sup>7</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	3.4	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4	4.5	4.9
Number of bricks.	2	2	4	5	4	3	12	5	4	3	2	3	1

<sup>8</sup> For the method of selection, see p. 395, n. 6.

the mean deviation .1 cm. In composition, texture, and hardness, also, no material difference is found. The color, however, is less uniform, varying from magenta or magenta yellow to clear yellow. The horizontal mortar joints are close, averaging a little over a centimetre, while the vertical joints average much less. Bonding courses do not appear.

No essential difference in type is found between the *opus caementicium* of the time of Tiberius, with its variant, *structura testacea*, and that of the time of Augustus. The specific characteristics, therefore, by which it is distinguished from the *opus caementicium* of the other periods are the same.

*Caligula*. — Under the porticus on the north of the so-called temple of Augustus, as well as within the building itself, the excavations of recent years have brought to light many fragmentary walls, which from their position and orientation may safely be accepted as part of the famous building by which Caligula sought, according to Suetonius,<sup>1</sup> to make of the temple of Castor the vestibule of his palace.<sup>2</sup> These walls, with a few belonging to the circus across the Tiber, which were identified in the seventeenth century but are now lost, are all which can be assigned, with any degree of certainty, to the time of Caligula.

The type of construction used in the walls of the circus is *opus caementicium* faced with *opus reticulatum* and brick.<sup>3</sup> The remains of the palace are, on the other hand, of *structura testacea*. The foundations are not visible. The walls, however, do not differ in type from those of the time of Augustus and Tiberius. The *caementa* are wholly of broken roof-tiles and the mortar is of the dusky red type characteristic of the general period. The few bricks of the facing which remain vary in width from 3.5 cm. to 4.5 cm., and resemble, in composition, texture, and color, also, those of the earlier part of the period. The horizontal mortar joints vary from 1 cm. to 1.5 cm.

<sup>1</sup> *Calig.* 22: *partem Palati ad forum usque promovit atque aede Castoris et Pollucis in vestibulum transfigurata*. . . . For Caligula's work as builder, cf. Pliny, *N.H.* XXXV, 111.

<sup>2</sup> The large basin under the library connected with the so-called temple, though it may have formed a part of the same palace originally, seems, in its present form, to belong to a later restoration.

<sup>3</sup> Nibby, *l.c.* I, p. 605.

## VI. THE PERIOD OF TRIANGULAR FACING BRICKS (CLAUDIUS-DOMITIAN)

The period of Claudius, though not conspicuous for the number or magnificence of its civil monuments, is yet distinguished by the boldness and technical skill displayed in carrying to completion the great monuments of engineering undertaken by Caligula. Of the more noteworthy of these, the aquae Claudia and Anio Novus and the emissarium of Lake Fucino, extensive remains have, by good fortune, been preserved to modern times.<sup>1</sup>

The period of Claudius is not without distinction, also, in its contributions to the art of building. In the materials used for walls of *opus quadratum* and in the body of the structures of *opus caementicium*, no change occurred at this time. Broken roof-tiles as a specific material for the *caementa* of walls were, however, given up and *structura testacea* as a distinct type of construction disappeared.<sup>2</sup> As facing bricks, also, broken roof-tiles were, for a time, abandoned, and in their place triangular bricks were introduced. Out of the union of this facing of triangular bricks with the earlier *opus caementicium* arose the typical Roman construction, brick-faced concrete.

For the parts above ground of the aqua Claudia and of a few other monumental structures,<sup>3</sup> the earlier construction in *opus quadratum* was retained. In the other greater monuments of the time, however, *opus caementicium* was used alone. Of the most important of these, the aqua Anio Novus, numerous remains are left. The general conclusions here given are, in large part, based upon the data derived from these remains and from those of the foundations of the aqua Claudia.<sup>4</sup>

Owing to the length of the aqueducts and the use, for the sake of economy, of materials found near at hand, a considerable

<sup>1</sup> The remains of the ancient emissarium were, unfortunately, in great part destroyed by the modern engineers in constructing the modern emissarium.

<sup>2</sup> No walls of *structura testacea* have been found which are later than the time of Caligula.

<sup>3</sup> The most important of these are the new arches of the aqua Virgo inside the city and the façade of the emissarium of Lake Fucino. (Brisse and Rotrou, *Dessèchement du Lac Fucino*, 1876, p. 252 and pl. VII, Fig. 1.)

<sup>4</sup> No critical examination of the aqueducts has as yet been possible except within a few miles of the city. Concerning the aqueducts as a whole, therefore, the conclusions here drawn are in no respect final.

difference in details is noticeable at various points in their course. The general type of construction, however, remains the same. The *caementa* in the foundations of the aqua Claudia<sup>1</sup> are of *selce*, with which, however, in the more massive portions of the Anio Novus, large pieces of red and yellow tufa are mixed. In the walls of the *specus* of the Anio Novus which

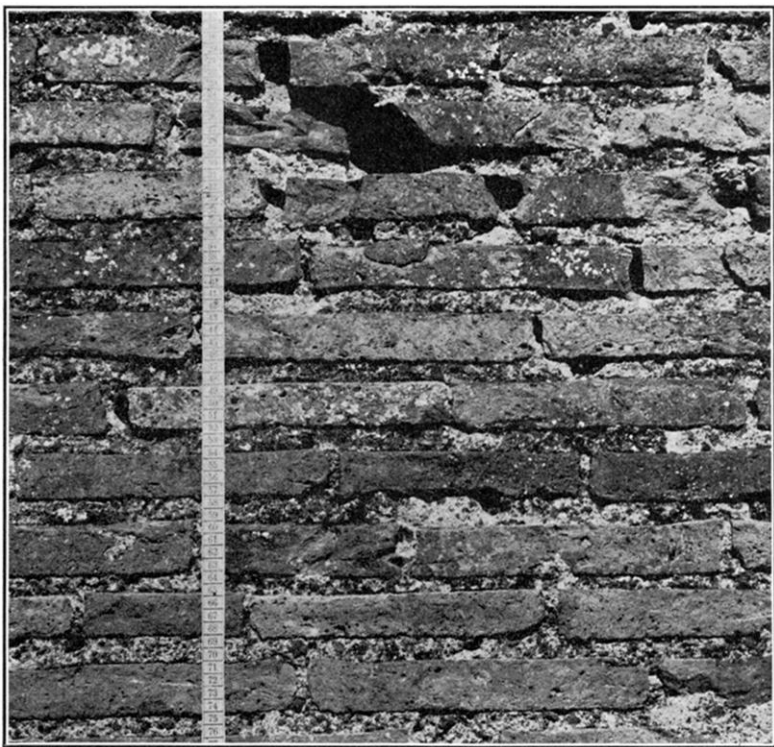


FIGURE 2. — FACING OF TRIANGULAR BRICKS OF THE TIME OF CLAUDIUS.<sup>2</sup>

are above ground,<sup>3</sup> the *caementa* are usually of peperino, the material used for the arches of the aqua Claudia, or of tufa. A few broken roof-tiles and pieces of brick are occasionally

<sup>1</sup> These are most conveniently seen a few miles from the city, near the point where the line of the aqueducts is crossed by the Naples railway.

<sup>2</sup> From the Anio Novus.

<sup>3</sup> The *specus* of the Anio Novus is most easily studied near the railway station of Capannelle.



found. The *caementa* of the roof of the *specus* differ little from those of the walls. The mortar varies considerably with the locality, but is, in general, of a reddish gray tone. The *arena*<sup>1</sup> consists, as a rule, of a reddish brown and gray *pozzolana*, somewhat *terrosa* in character, with which is mixed, at times, a considerable quantity of coarse gravel. The lime is of a medium good quality but is often deficient in quantity.

The facing is of three kinds, *opus reticulatum*, *opus reticulatum* with *opus testaceum*, and *opus testaceum* (Fig. 2). The *opus reticulatum* is found only in certain parts of the inner facing of the *specus*, the other parts of which are faced with *opus testaceum*. The outside of the *specus* is faced with *opus reticulatum* and *opus testaceum* or with *opus testaceum* alone. The *opus reticulatum* is made usually of a yellowish gray or a light red tufa belonging to the region. The *tesserae* measure across the face from 7 cm. to 7.5 cm. The *opus testaceum* used in the facing of the outside of the *specus* is made wholly, so far as seen, of triangular bricks made from the small square bricks,<sup>2</sup> called *laterculi bessales*.<sup>3</sup> On the inside, smaller triangular bricks, as well as a number of broken roof-tiles, are occasionally found. The larger triangular bricks are normally from 3.8 cm. to 4.2 cm. wide. The average width of 100,<sup>4</sup> which may be regarded as representative, is 4 cm. and the mean deviation .1 cm. In length, they vary from 17 cm. to 27 cm., rarely exceeding 28 cm.<sup>5</sup> The clay and the red *pozzolana* of which they are made are carefully sifted and well mixed, or puddled. They

<sup>1</sup> The *arena* used for the mortar of the emissarium of Lake Fucino was, according to Brisse (*l.c.* p. 28), a ferruginous lake sand, although a good variety of *pozzolana* is found in the region, which, however, may not have been recognized by the Romans on account of its yellow color.

<sup>2</sup> For the source of triangular bricks and the method of preparation, see the previous paper, p. 236.

<sup>3</sup> Vit. *l.c.* V, X, 2.

<sup>4</sup> The exact width of the bricks is as follows:

Measurement in centimetres.	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4
Number of bricks.	2	2	2	1	8	45	18	17	3	2

<sup>5</sup> The source of the various facing bricks is often indicated by their length. Cf. the length of the roof-tile facing bricks of the Augustan period, p. 395.

are of medium fine texture and are well fired. Their color varies normally from a yellowish red to a reddish yellow, approaching, at times, a magenta yellow.<sup>1</sup> The mortar is slightly finer than in the body of the structure. The horizontal joints vary from 1.5 cm. to 2 cm. and are carefully raked. The vertical joints average a little more than 1 cm. No bonding courses appear.

The principal characteristics by which the monuments of *opus caementicium* of the time of Claudius are most readily distinguished from those of the preceding periods are: (1) the color of the mortar, and (2) the use of triangular bricks either alone or with *opus reticulatum*. They are, on the other hand, distinguishable, though less easily, from the monuments of Nero and the Flavians (1) by the presence of *opus reticulatum*, and (2) by the quality and width of the triangular bricks.

*Nero.*—During the earlier years of his reign, Nero displayed his passion for building in the magnificent group of monuments which he erected in the Campus Martius and in the vast palace by which he united the Palatine and the gardens of Maecenas on the Esquiline. In creating a new city, however, on the broad areas laid waste by the great fire, he for the first time found full opportunity for the gratification of his ambition. With the year 64, therefore, begins properly the second great building period of imperial Rome.

In order that his new capital might not be so easily swept away by another conflagration, Nero, by the expenditure of vast sums of money as well as by the establishment of a number of new building regulations,<sup>2</sup> brought about a series of changes which affected not only the general plan of the city but also the type of construction used in its new edifices. Of the changes affecting the city as a whole, the most important were: <sup>3</sup> (1) the adoption of a new *piano regolatore*, at least for the centre of the city; (2) the widening and straightening of the streets and the creation of spacious open squares; (3) the isolation of the houses, by abolishing the use of "common walls" and by the introduction of colonnades, or porticos,

<sup>1</sup> The clear magenta red tone of the earlier tile bricks very rarely, if ever, appears in triangular bricks.

<sup>2</sup> Tac. *Ann.* XV, 43.

<sup>3</sup> For these changes, see Tacitus, *l.c.*

along their fronts.<sup>1</sup> In connection with these more general changes, others of a more specific character took place, which were not without importance in their influence on the development of Roman construction. Among the most conspicuous of the results which attended these more specific changes were: (1) the more general adoption of peperino and other fireproof materials, especially for walls of *opus quadratum*; (2) the more intelligent choice of materials for the *caementa* of the various parts of concrete structures; and (3) the universal use at Rome, in public monuments, of triangular bricks for wall facing, in place of the less practical facing of *opus reticulatum* or roof-tiles.

Though it is clear, from the prescribed use of peperino,<sup>2</sup> that *opus quadratum* retained its place, in the new city, for certain buildings or parts of buildings, remains of structures made of it either alone or in combination with *opus caementicium* are rare. Monuments of *opus caementicium* faced with *opus testaceum* are, on the contrary, to be found on every hand.

The type of construction used in these monuments is very regular. The *caementa* consist almost entirely of refuse materials from the buildings destroyed by the fire. In the foundations and substructures,<sup>3</sup> in the larger number of the monuments, travertine is used in great abundance,<sup>4</sup> with a smaller quantity of reddish or light brown tufa, peperino, and *selce*. In certain parts of the domus Aurea, however, the *caementa* are almost wholly of *selce*. Small pieces of broken and charred marble and a few bricks are found also. The pieces are, as a rule, of medium size. In the walls, the *caementa* are almost wholly of broken roof-tiles and other bricks, of the same or earlier periods, laid in irregular rows. The *caementa* in the vaults are consistently of large pieces of yellowish gray tufa. The mortar is of a dark gray or reddish gray type,<sup>5</sup> coarse in its composition and, at times, somewhat friable. The *arena* consists of an inferior quality of *pozzolana*, coarsely sifted and

<sup>1</sup> Nissen (*Pomp. Stud.* p. 371) calls attention to the introduction at Pompeii by Nero, a few years earlier, of similar colonnades.

<sup>2</sup> Tac., *l.c.*

<sup>3</sup> See the previous paper, p. 234, Fig 2.

<sup>4</sup> See the wall in the figure just referred to.

<sup>5</sup> Cf. the ashy gray mortar of the republican period, *l.c.*, pp. 245, 247.

slightly *terrosa*, the prevailing tone of which is dark gray, but with an admixture of red, reddish brown, and white particles. The lime is of an inferior quality and, at times, is deficient in quantity also.

The facing of the walls in Rome<sup>1</sup> is, without exception, of *opus testaceum* made of triangular bricks (Fig. 3). These bricks

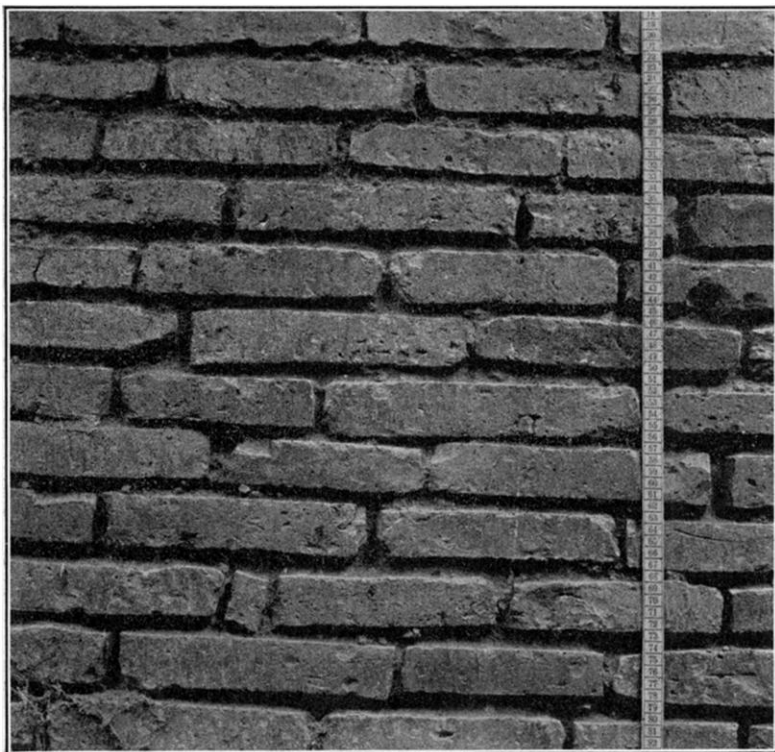


FIGURE 3. — FACING OF TRIANGULAR BRICKS OF THE TIME OF NERO.<sup>2</sup>

are normally from 3.9 cm. to 4.5 cm. wide, being rarely found less than 4 cm. The average width of 100 bricks<sup>3</sup> from the

<sup>1</sup> Outside of Rome, as at Anzio, *opus reticulatum* also is used.

<sup>2</sup> From the domus Aurea.

<sup>3</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4	4.5	4.6
Number of bricks.	1	1	1	5	35	18	23	5	1	8	2

atrium Vestae, the domus Aurea, and the arcus Neroniani is 4.1 cm. and the mean deviation .1 cm. The length of the bricks is usually from 25 cm. to 28 cm., never, so far as seen, exceeding 30 cm.<sup>1</sup> Many broken bricks are, however, found, especially in the domus Aurea. The bricks are very poor in composition, consisting of a heterogeneous mass of clay and coarse *pozzolana*, badly mixed and full of holes. They are, however, well fired. They vary in color from reddish yellow to yellowish red and are conspicuous for their streaked and mottled appearance. The horizontal joints of mortar are normally from 1.5 cm. to 2 cm. wide and are, normally, raked. The vertical joints are somewhat irregular, but are commonly from .5 cm. to 1.5 cm.

Bonding courses of the wide yellow *bipedales* regularly used for the arches appear sporadically in the arcus Neroniani.

The principal monuments of *opus caementicium* of the period of which remains still exist are the following:<sup>2</sup>

The thermae of Nero (62 A.D.).<sup>3</sup>

The domus Transitoria: fragmentary walls on the Velia (?) (before 64 A.D.).

The atrium Vestae: the imperial atrium of the first period (64-68 A.D.).<sup>4</sup>

The shops on the north of the atrium Vestae (64-68 A.D.).<sup>5</sup>

The porticus along the Sacra Via on the Velia<sup>6</sup> (64-68 A.D.).

The porticus along the clivus Palatinus<sup>7</sup> (64-68 A.D.).

The domus Aurea (64-68 A.D.).

The Sette Sale (64-68 A.D.).

The arcus Neroniani (64-68 A.D.).

The general characteristics, or "earmarks," which distinguish the *opus caementicium* of the time of Nero are: (1) the

<sup>1</sup> Since the front of these bricks (*laterculi bessales*) is the diagonal of a square of 20 cm. to 22 cm., the greatest length possible is 31 cm.

<sup>2</sup> For the monuments included in this list, see p. 389, n. 5.

<sup>3</sup> Nibby, *R.A.* II, 775-776.

<sup>4</sup> Van Deman, *The Atrium Vestae*, pp. 19 f. and Plan A.

<sup>5</sup> Van Deman, *l.c.*, pp. 18, 19. These shops form part of an extensive group on the Velia, which will be discussed at a later time.

<sup>6</sup> The massive substructures of unfaced concrete opposite the basilica of Constantine formed the foundations for the porticus on the south side of the Sacra Via. Traces of a corresponding porticus exist on the opposite side.

<sup>7</sup> This porticus is the continuation of that just described (n. 6).

dark gray tone of the mortar, and (2) the poor composition, porosity, and mottled appearance of the bricks, as well as their width.

*Vespasian.* — With the rise of Vespasian to imperial power, a period of wise conservation and reorganization began throughout the realm. A new impulse was given also to the rebuilding of the city, still half buried in ruins,<sup>1</sup> and to the restoration of the public utilities, so sadly neglected by Nero.

In the history of construction, likewise, the reign of Vespasian is one of reorganization, marked not so much by the introduction of new materials and methods as by the intelligent and economical use and skilful combination of those already existing. That this was the result not only of regard for economy but also of sound knowledge is shown by the retention of the same type of construction throughout the whole of the Flavian period.

The most important of the changes which were brought about by the building policy of Vespasian were: (1) the selection of *selce* as the preferred material for the *caementa* of foundations and other massive construction; (2) the reintroduction of the earlier clean red *pozzolana* in place of the poorer grayish variety used in the buildings of Nero; and (3) the adoption of a narrower and more homogeneous type of triangular bricks for the facing of walls.

*Opus quadratum* appears prominently in the public monuments of the time, and in the Colosseum is united in a most effective way with the massive walls of *opus caementicium*. The remains of the forum of Peace and of the temple of *Sacra Urbs* are wholly, at least above ground, of *opus quadratum*. The aqua Claudia and the Anio Novus are, on the other hand, restored in *opus caementicium* faced with triangular bricks.

The *opus caementicium*, though lacking the technical perfection of the next general period, is of a good quality. The *caementa* of the foundations are almost wholly, so far as seen, of *selce*. The pieces are of medium size and are laid with no attempt at order. In the walls, the *caementa* are normally of triangular bricks of the same or of the earlier period, which are laid on

<sup>1</sup> See Tac. *Ann.* XV, 41. Suet. *Vesp.* VIII, 5; IX, 1.

the flat side in somewhat even rows. Flanged tiles are also found and occasionally other old materials, as tufa or travertine. The vaults are constructed wholly of *caementa* made of large pieces of yellowish gray tufa.<sup>1</sup> The mortar is of a dirty-white and red type. While not as fine grained as in the

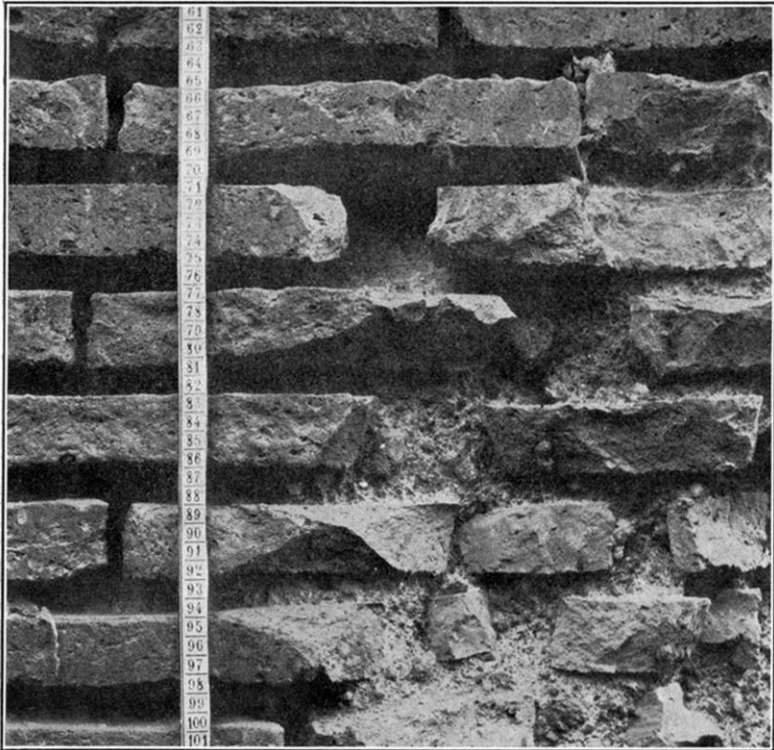


FIGURE 4.—FACING OF TRIANGULAR BRICKS OF THE TIME OF VESPASIAN.<sup>2</sup>

following period,<sup>3</sup> it is firm and tenacious. The *pozzolana-arena* is sharp-angled and clean, though, at times, very coarse. Its predominating color is red, though reddish brown and gray particles appear also.

<sup>1</sup> The character of the *caementa* is very important in the upper stories of the Colosseum, where by contrast the restorations are most easily recognized in the small pieces of dark pumice stone used for the *caementa*.

<sup>2</sup> From the Colosseum. The distance is 1 m. instead of 1.5 m. as in the other figures.

<sup>3</sup> Cf. the periods of Trajan and Hadrian, pp. 415, 418.

The facing is of *opus testaceum* of triangular bricks (Fig. 4), with almost no admixture of old material.<sup>1</sup> The bricks are usually from 3.7 cm. to 4.2 cm. wide. The average width of 100<sup>2</sup> from the Colosseum is 3.9 cm. and the mean deviation .1 cm. Their length varies from 20 cm. to 30 cm. They are much more homogeneous in composition and of far finer texture than the bricks of the Neronian time. In color they vary from reddish yellow to yellowish red, but are comparatively free from the streaked and mottled appearance so noticeable in the bricks of the time of Nero. They are hard baked and weather well, showing little tendency to disintegration. The horizontal mortar joints are somewhat closer than in the Neronian walls, varying from 1.2 cm. to 1.7 cm. and are carefully raked. The vertical joints average a little less than 1 cm.

Bonding courses do not appear in any of the walls of the time.

The principal monuments or parts of monuments of the time of Vespasian which are made of *opus caementicium* are the following:

The aquae Claudia and Anio Novus: general restorations (71 A.D.).

The Colosseum: the substructures, the inner walls of the first and second stories, and of a part of the third story (78 A.D.).

The porticus (?) north of the Colosseum: fragmentary walls (78 A.D.?).

The cloaca in front of the Colosseum (78 A.D.).<sup>3</sup>

The porticus Claudia (?).<sup>4</sup>

The principal characteristics by which the *opus caementicium* of the time of Vespasian<sup>5</sup> is most readily distinguished from that

<sup>1</sup> Cf. the period of Maxentius, p. 431.

<sup>2</sup> The exact width of the bricks is as follows:

Measurement in centimetres.	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3
Number of bricks.	2	9	11	21	47	4	4	2

<sup>3</sup> Narducci, *Fognatura di Roma*, p. 68.

<sup>4</sup> Platner, *Top.* (1911), p. 439.

<sup>5</sup> The distinctive characteristics of the whole Flavian age are the same as those of the time of Vespasian, except for the appearance, in the time of Domitian, of bonding courses.



of the Neronian period are: (1) the dirty-white and red color of the mortar, and (2) the width and composition of the bricks. The absence of bonding courses is the only noticeable difference between the *opus caementicium* of the time of Vespasian and that of the later Flavian emperors.

*Titus.* — Titus, succeeding quietly to his father's rule, sought, for the most part, merely to carry out the undertakings already begun. A few new public monuments were, however, erected by him. The most important of these monuments, two of which were left unfinished at his death, were the *thermae Titianae*, and the temple of Vespasian with the porticus *Deorum Consentium* adjoining it. He restored, also, the Marcian and the Claudian aqueducts. Of the other monuments built during his reign, but two are of especial importance, the arches of Titus in the Circus Maximus and on the Velia.

To the art of building not only did Titus' short reign of two years contribute nothing, but the changes so wisely inaugurated by Vespasian lost much of their force in the hands of his less efficient son. This is to be seen most clearly in the hasty choice of materials and in the careless methods of construction, especially noticeable in the porticus *Deorum Consentium*, to which no less than to the *thermae* might be applied Martial's well known expression *velocia munera*.<sup>1</sup>

As in the time of Vespasian, *opus quadratum* maintained its place in a few monuments, though of little structural value in comparison with the *opus caementicium* with which it was united. The restoration of the aqua Marcia was wholly in *opus caementicium*.

In general type, the *opus caementicium* does not differ from that of the time of Vespasian. For the *caementa*, however, much more old material was used. In the few remaining arches of the restoration of the aqua Marcia inside the city, for example, they consist almost wholly of *opus reticulatum* blocks of yellowish gray tufa, belonging to earlier republican houses in the vicinity. The mortar also is less homogeneous, as well as less tenacious than earlier, on account of the earthy nature of the *pozzolana-arena* used. The facing of the walls does not differ from that of Vespasian's time, except in the

<sup>1</sup> *Spect.* 2. Cf. Suet. *Tit.* 7: *thermisque iuxta celeriter exstructis.*

more frequent appearance of older material. The triangular bricks used are normally from 3.7 cm. to 4.1 cm. wide. The average width of 25<sup>1</sup> from the restored arches of the aqua Marcia inside the city and the porticus Deorum Consentium is 3.9 cm. and the mean deviation .1 cm. The joints of mortar, both horizontal and vertical, are very irregular in width.

The monuments or parts of monuments of the time which are built of *opus caementicium* are the following:

The aqua Marcia: the restored arches, especially those near the porta Tiburtina (79 A.D.).<sup>2</sup>

The temple of Vespasian: the podium.<sup>3</sup>

The porticus of the Dei Consentes: the lower rooms.<sup>4</sup>

The arch of Titus on the Velia: the foundations.<sup>5</sup>

The thermae of Titus: a few fragmentary walls (?) (81 A.D.).

No specific characteristics have as yet been found by which the *opus caementicium* of this time may be distinguished with certainty from that of the other Flavian emperors.

*Domitian.* — The new city was arising slowly from the ashes of the fire of Nero, when, in 80 A.D., it suffered from a second conflagration, which not only destroyed many of the newly restored monuments, but swept over much of the city which had before escaped destruction. In the rebuilding of the monuments thus destroyed and the erection of splendid new ones in every part of the city, Domitian found ample opportunity to gratify his feverish passion for building.<sup>6</sup>

But although, in the number and magnificence of its monuments, the reign of Domitian may be regarded as one of the great building periods of Rome, it contributed little to the

<sup>1</sup> The exact width of the bricks is as follows:

Measurement in centimetres.	3.6	3.7	3.8	3.9	4	4.1	4.2
Number of bricks.	1	1	5	3	13	1	1

<sup>2</sup> The walls inside the earlier arches of the aqua Marcia are the best work which is left of the time of Titus.

<sup>3</sup> The temple was finished by Domitian.

<sup>4</sup> The porticus seems to have been finished by Domitian.

<sup>5</sup> The arch was finished by Domitian.

<sup>6</sup> Plutarch (*Popl.* 15) applies the name *νόστος* to this passion.

development of the art of construction. *Opus quadratum* retains a prominent place, though there is a perceptible decrease in the amount used in the buildings where it is united with *opus caementicium*. A larger number of important monuments are, moreover, built wholly of *opus caementicium*, as, for example, the so-called temple of Augustus, the atrium Vestae of the

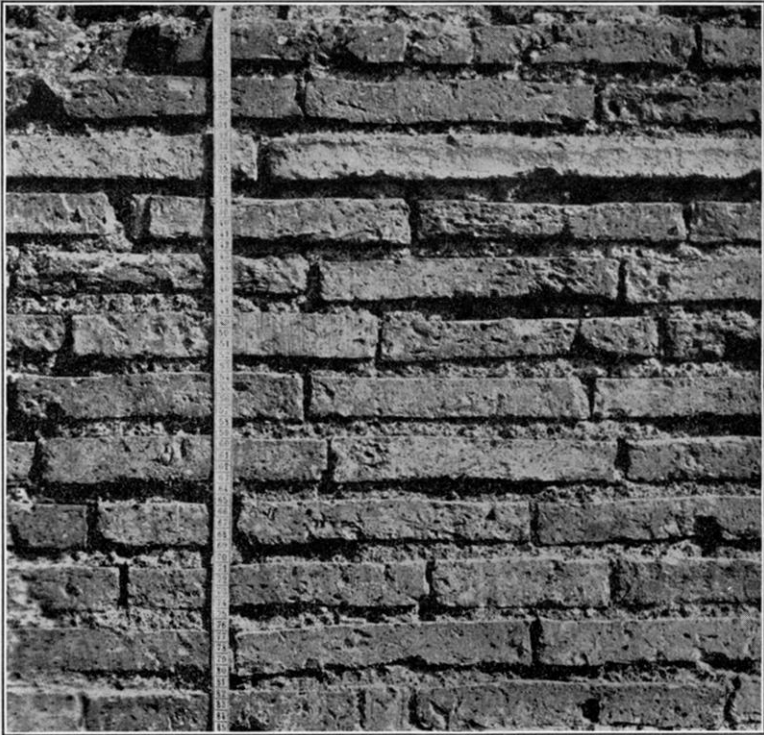


FIGURE 5.—FACING OF TRIANGULAR BRICKS OF THE TIME OF DOMITIAN.<sup>1</sup>

second period, the palaces on the Palatine, and the stadium in the Campus Martius.

In type, the *opus caementicium* of Domitian resembles closely that of the time of Vespasian. The *caementa*,<sup>2</sup> however, show

<sup>1</sup> From the domus Augustana. Cf. the previous paper, p. 233, Fig. 1; p. 238, Fig. 4; p. 240, Fig. 6.

<sup>2</sup> The use of yellowish gray tufa for the *caementa* of one of the walls of the ramp leading from the temple of Augustus to the Palatine is very exceptional. For the *caementa* of the period, see the previous paper, p. 249, Fig. 8.

a larger proportion of broken triangular bricks and marble. The mortar is the same in composition and color, but is somewhat coarser, especially in foundations.

The facing (Fig. 5) does not differ in type from that of Vespasian.<sup>1</sup> The bricks are normally from 3.6 cm. to 4.2 cm. wide. The average width of 200<sup>2</sup> from the so-called temple of Augustus, the atrium Vestae, the domus Augustana, and the Meta Sudans is 3.9 cm. and the mean deviation .1 cm. The length varies normally from 25 cm. to 29 cm., never exceeding, so far as seen, 30 cm. The horizontal mortar joints vary from 1.3 cm. to 1.8 cm. and are, normally, raked. The vertical joints are from .5 cm. to 1.2 cm. wide.

Bonding courses are introduced at regular intervals, commonly 16 to 18 or 28 to 30 courses apart, and extend through the whole width of the wall. They are made of heavy *bipedales*, 4.5 cm. to 5 cm. thick, and are of a light yellow or a magenta yellow color.

The monuments or parts of monuments of the period in which *opus caementicium* is used are the following:

The so-called temple of Augustus<sup>3</sup> and the library adjoining it (before 90 A.D.).

The temple of Vesta: the *favissa* (before 91 A.D.).

The atrium Vestae: the imperial atrium of the second period (before 91 A.D.).<sup>4</sup>

The Equus Domitiani: the foundations<sup>5</sup> (91 A.D.).

The domus Augustana (before 92 A.D.).

The Hippodromus on the Palatine (before 92 A.D.).

The Meta Sudans (97 A.D.).

The temple of Vespasian: the portion left incomplete by Titus.

<sup>1</sup> In the villa of Domitian at Castel Gondolfo, the facing is of *opus reticulatum* and *opus testaceum*.

<sup>2</sup> The exact width of the bricks is as follows:

Measurement in centimetres.	3	3.2	3.4	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3
Number of bricks.	1	1	1	6	10	17	31	29	81	13	9	1

<sup>3</sup> This monument will be discussed in a following paper.

<sup>4</sup> Van Deman, *The Atrium Vestae*, pp. 21 ff. and Plan B.

<sup>5</sup> See the previous paper, p. 249, Fig. 8.

The porticus Deorum Consentium : the upper story.

The small room between the temples of Vespasian and Concord (?).<sup>1</sup>

The house of Avidius Quietus.<sup>2</sup>

The stadium in the Campus Martius (?) (not yet classified).

The tomb of Domitilla (?) (not yet classified).

The restorations of the aquae Marcia and Claudia (not yet classified).

In the monuments of *opus caementicium* of the time of Domitian, when compared with those of the earlier Flavian period, no distinctive characteristics are found, apart from the use of bonding courses. When compared with the monuments of the succeeding periods, however, the buildings of Domitian's time, like those of the time of the earlier Flavian emperors, are easily distinguished by the type of the mortar, as well as by the use of triangular facing bricks.

## VII. THE PERIOD OF THE REVIVAL OF ROOF-TILE FACING (TRAJAN-MARCUS AURELIUS)<sup>3</sup>

*Trajan.* — In the monuments which bear the name of Trajan, few in number but conspicuous for their refinement in architectural forms and in construction, one recognizes the expression of a genius but little akin to that which produced the strong but cruder monuments of the Flavian age. It is probable that to the Syrian Greek, Apollodorus, is due the appearance of the new artistic feeling, which, being allowed full play by the emperor Trajan, brought the Roman art of building in concrete to its fullest development.

No distinctly new principles and few, if any, new materials and methods were, so far as can be determined, introduced. On the contrary, Apollodorus, retaining those which had been proved of real value during the preceding half century, evolved from them a higher type of construction, by uniting with them certain materials and methods from the earlier age of Augustus.

<sup>1</sup> This room may have been built by Titus.

<sup>2</sup> Hülsen-Jordan, *Top.* p. 344, n. 2.

<sup>3</sup> The failure to recognize the existence of two distinct periods of roof-tile facing has led to many of the errors in the chronology of the monuments.

The main features in the monuments of the period which mark an advance in the type of construction are :

(1) The abandonment of the use of *opus quadratum* for points of special pressure, as well as for external walls.

(2) The marvellous adaptation not only of the different materials but of the different grades of the same material to the structural demands of the various buildings or parts of a single building.

(3) The finished technique, especially noticeable in the fineness and homogeneous quality of the mortar used in the various parts of the structures, as well as in the regularity and beauty of the facing.<sup>1</sup>

(4) The extensive use of sawed roof-tiles not only for the facing but also for the decorative parts even of important public monuments.

While *opus quadratum* continued to be used in certain parts, at least, of many monumental structures, the age of Trajan is especially marked by the extension of the use of *opus caementicium* to all classes of buildings, including aqueducts and other monuments of engineering.<sup>2</sup>

The *opus caementicium* of this time differs much both in appearance and in quality from that of the Flavian Age. The *caementa* in the foundations, where these are to be seen, are of *selce*, with which is mixed occasionally a little travertine. The pieces are of medium size. In the walls broken bricks of all kinds are found, which are laid in close, though somewhat irregular, rows.<sup>3</sup> For the vaults, as earlier, yellowish gray tufa is used. The mortar is of a clean-white and red type, very compact and almost flint-like in hardness. The *arena* is composed of a clean red *pozzolana*, with a slight admixture of reddish brown and gray particles. It is very "sharp," finely sifted, and free from any earthy quality.<sup>4</sup> The lime is more abundant

<sup>1</sup> Of the concrete monuments in Rome, the most conspicuous for the elegance as well as the excellence of their construction are the forum of Trajan and the amphitheatrum Castrense.

<sup>2</sup> For the general value assigned to *opus caementicium* faced with *opus testaceum*, see Pliny, *Ep. ad Traianum*, XXXVII, 2; XXXIX, 4.

<sup>3</sup> In the aqua Traiana near the city, the reddish brown tufa of which the *opus reticulatum* of the facing is made is used also for the *caementa*.

<sup>4</sup> It is probable that the *pozzolana* was washed to remove the fine dust so noticeable in the mortar of the time of Augustus. See p. 392.

than earlier and is very clean and white, being excelled in whiteness only by that used in the monuments of the time of Hadrian.

The facing is normally of *opus testaceum* made of broken roof-tiles, with which, in a few monuments, *opus reticulatum* is mixed.<sup>1</sup> These tile bricks are narrower than those of the earlier period. They tend, also, more often, to approach the triangular form. They are normally from 3.3 cm. to 4.1 cm. wide. The average width of 200<sup>2</sup> from the five more important monuments of the time is 3.7 cm. and the mean deviation .2 cm. Their length varies usually from 20 cm. to 33 cm.<sup>3</sup> In composition they differ but slightly from the earlier type. They are of a very fine texture and are well fired, having a metallic ring when struck. Their color is commonly magenta red, though of a slightly lighter tone than that of the earlier tile bricks. A small number also are of a yellowish magenta or clear yellow color.<sup>4</sup> The width of the horizontal joints of mortar is normally from .7 cm. to 1.5 cm., and of the vertical joints, from .5 cm. to .8 cm. The horizontal joints are carefully raked.

In several monuments of the time, a finer variety of facing is used for the fronts of the walls. The tile bricks used in this facing, however, do not differ in kind from those just described. The horizontal mortar joints are, however, very close, varying from .3 cm. to .7 cm., while the vertical joints are almost invisible.

<sup>1</sup> The most important of the monuments in which *opus reticulatum* is found are the aqua Traiana and the Naumachia (Hülsen-Jordan, *l.c.* pp. 660 f.). It appears also in a single wall in the *thermae*.

<sup>2</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7
Number of bricks.	1	2	6	12	18	32	20	21

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Measurement in centimetres.	3.8	3.9	4	4.1	4.2	4.3	4.5	5
Number of bricks.	28	23	26	7	1	1	1	1

<sup>3</sup> Cf. the length of triangular bricks, pp. 402, 406, 409, 413.

<sup>4</sup> It is possible that these bricks may be made in part from *bipedales*.

Bonding courses of the thick, light-colored *bipedales* used for arches occur regularly in the Forum, but are found less often in the other monuments.

The monuments or parts of monuments of the time which are made of *opus caementicium* are the following:

The thermae of Trajan (of an early date).

The aqua Traiana (109–10 A.D.).<sup>1</sup>

The thermae of Sura (109–10 A.D.).<sup>2</sup>

The arch of Trajan: the foundations.<sup>3</sup>

The forum of Trajan: the foundations, and the walls of the hemicycles (112–14 A.D.).

The basilica Ulpia: the foundations (112–14 A.D.).

The column of Trajan: the foundations (112–14 A.D.).

The bibliothecae: the foundations and a part of the walls (112–14 A.D.).

The extension of the Circus Maximus: probable walls at the east end.

The Naumachia.<sup>4</sup>

The extension of the aqua Marcia to the Aventine: arches near the Porta Capena.<sup>5</sup>

The amphitheatrum Castrense.<sup>6</sup>

The main characteristics which distinguish the monuments of *opus caementicium* of this time from those of the preceding period are (1) the clean-white and red color of the mortar as well as its fine composition and flint-like hardness, and (2) the use of roof-tile facing bricks. No marked differences are found, on the other hand, between the type of construction of this time and that of the time of Hadrian.

*Hadrian.* — During the early years of his reign, Hadrian conformed his policy in general to that of his predecessor and kinsman. The earlier monuments, therefore, erected under the

<sup>1</sup> The data for the aqua Traiana are not as yet complete.

<sup>2</sup> The data for the thermae of Sura are as yet incomplete.

<sup>3</sup> Pellegrini *ap.* Jordan, *Top.* I, 2, p. 457, n. 26.

<sup>4</sup> Hülsen-Jordan, *l.c.* pp. 660 f. Cf. Durm, *Baukunst der Römer* (1904), p. 699, Fig. 766.

<sup>5</sup> The data for this monument are as yet incomplete.

<sup>6</sup> The assignment by Hülsen (Hülsen-Jordan, *l.c.* p. 249, n. 74) of the amphitheatrum Castrense to Trajan is proved correct by many structural as well as architectural peculiarities of the monument.



influence of the building traditions of the previous period, if not under the immediate direction of its great architect, Apollodorus, differ but little from those of the time of Trajan. The later monuments, on the other hand, erected by the emperor after his years of travel and study of the monuments of other lands, resemble less closely those of the preceding period. Their gain in originality is, however, counterbalanced by a noticeable loss in perfection of form and technique, owing, possibly, to the fall from favor, at this time, of the master architect, Apollodorus.

Although no period did more to assist in the extension of the use of Roman concrete, few, if any, important contributions were made to the history of the development of the construction. The materials and methods of the time of Trajan were, in the main, adopted without change. In a few of the later monuments, however, triangular bricks were again used.<sup>1</sup>

Monuments built wholly or in part of *opus quadratum* are rare. For all classes of structures, on the other hand, *opus caementicium* was regularly used.

Throughout the whole period the *opus caementicium* is conspicuous for its uniformity, even in details.<sup>2</sup> The *caementa* in the foundations are almost entirely of *selce*, except in a very few walls on the Palatine, where a large amount of broken travertine and marble appears. In the temple of Venus and Rome also, tufa was substituted for *selce* in the portions of the podium upon which the lighter parts of the superstructure rested. The *caementa* of the walls are commonly of bricks of various kinds laid in closely packed rows. In the walls of the porticus of the domus Augustana, however, much broken marble and travertine is found. For the *caementa* in vaults, the lighter tufas were used. The mortar is of the clean-white and red type, and is conspicuous for its fine composition, cohesiveness, and rock-like hardness. The *pozzolana-arena* is sharp-angled, fine, and noticeably clean, being possibly washed as well as sifted. Its predominating color is red, though,

<sup>1</sup> See below, p. 420.

<sup>2</sup> This uniformity, which is noticeable also in the buildings of the period in other lands, was probably due to the personal interest of the emperor in the erection of public monuments.

in certain monuments, considerable reddish brown and gray appear. The lime is exceptional in its fine quality and clear white color.

The facing of the greater number of the monuments of the period in Rome<sup>1</sup> is *opus testaceum* (Fig. 6), though in a few



FIGURE 6. — ROOF-TILE FACING OF THE TIME OF HADRIAN.<sup>2</sup>

cases *opus reticulatum* appears.<sup>3</sup> In the more important monuments, the *opus testaceum* is made wholly of broken roof-tiles of the same type as those used earlier. These bricks do not differ materially in width from those of the time of Trajan,

<sup>1</sup>The use of *opus reticulatum* is more common in the vicinity of Rome than in the city itself. In the villa at Tivoli *opus reticulatum*, *opus reticulatum* with *opus testaceum*, and *opus testaceum* are all used.

<sup>2</sup> From the Pantheon.

<sup>3</sup> *Opus reticulatum* appears in the walls at the northeast corner of the Palatine, and in the domus Cilonis (Hülse-Jordan, *l.c.* p. 188, n. 15 a).

varying normally from 3.3 cm. to 4 cm. The average width of 100<sup>1</sup> from the Pantheon, which may be accepted as typical, is 3.7 cm. and the mean deviation .2 cm. They vary in length from 25 cm. to 35 cm.<sup>2</sup> In composition, texture, and color, they resemble, in general, the tile bricks of the previous period. They are, as a rule, however, much less carefully fired. The mortar is somewhat finer than that used in the body of the structure. The horizontal joints are usually from 1 cm. to 1.6 cm. wide and are carefully raked. The vertical joints vary from .5 cm. to .9 cm.

In a small number of walls of the time in the domus Augustana on the Palatine,<sup>3</sup> the facing is of triangular bricks. These triangular bricks, while they resemble, in general, those of the earlier period, are marked by certain distinctive characteristics.<sup>4</sup> They differ noticeably in width, seldom exceeding 3.6 cm. or 3.7 cm. The average width of 25,<sup>5</sup> which are fairly typical, is 3.5 cm. and the mean deviation .1 cm. In length they show, naturally, no difference from the earlier type, since they are made from similar *bessales*, 20–22 cm. square. They are, however, more homogeneous in composition, of finer texture and, as a rule, better puddled ; they are equally well fired. In color they vary, as earlier, from yellowish red to reddish

<sup>1</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	2.8	3	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3
Number of bricks.	1	1	5	9	15	10	14	16	6	16	4	2	1

<sup>2</sup> As a means of distinguishing the various types of facing bricks, the length is very important.

<sup>3</sup> A part of the cross walls of the colonnade on the west. For one of these walls, see the previous paper, p. 238, Fig. 4. Other important walls of the same type will be discussed in a later article.

<sup>4</sup> Cf. the triangular bricks of Claudius (p. 402), Nero (p. 405), and the Flavians (p. 409).

<sup>5</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	3.2	3.3	3.4	3.5	3.6	3.7	3.8
Number of bricks.	2	5	4	5	4	2	3

yellow, but are largely free from the mottled and streaked appearance especially characteristic of the Neronian bricks. The mortar in the body of the structure and in the facing is the same as that in the walls faced with roof-tiles.

The monuments or parts of monuments of this time for which *opus caementicium* was used are the following :

The temple of Trajan : the foundations (*ca.* 119 A.D.).<sup>1</sup>

The Pantheon (126 A.D. or later).

The thermae of Agrippa : the walls immediately behind the Pantheon (126 A.D. or later).<sup>2</sup>

The temple of Venus and Rome : the podium (135 A.D.).

The domus Augustana : the cross walls of the colonnade and a number of walls inside the building (135 A.D. or later).

The mausoleum of Hadrian (138 A.D.).

The atrium Vestae : the imperial atrium of the third period.<sup>3</sup>

The domus Cilonis.<sup>4</sup>

The walls at the northeast corner of the Palatine.<sup>5</sup>

The more regular use of bonding courses is the only marked characteristic by which the monuments of *opus caementicium* of the time of Hadrian may be distinguished from those of the periods immediately preceding and following it.

*Antoninus Pius-Commodus.* — The number of monuments of the time of the Antonines which are made either wholly or in part of *opus caementicium* is very small. The type of construction in these monuments is identical, except for the absence of bonding courses, with that used in the time of Hadrian.

The only important monuments of the time, as yet identified, in which *opus caementicium* appears are :

The temple of Antoninus and Faustina : the foundations.

The atrium Vestae : the imperial atrium of the fourth period.<sup>6</sup>

<sup>1</sup> *Bull. d. Ist.* 1869, p. 237 ; *Not. Scav.* 1886, pp. 158 ff.

<sup>2</sup> No trace has been found as yet of the original walls of the time of Agrippa.

<sup>3</sup> Van Deman, *l.c.* pp. 33 f. and Plan C.

<sup>4</sup> Hülsen-Jordan, *l.c.* p. 188, n. 15 a.

<sup>5</sup> These walls are correctly assigned by Richter (*Top.* p. 151) to the time of Hadrian.

<sup>6</sup> Van Deman, *l.c.* p. 42 and Plan D.

# VIII. THE PERIOD OF FACING BRICKS OF BROKEN BIPEDALES (SEPTIMIUS SEVERUS-DIOCLETIAN)<sup>1</sup>

*Septimius Severus-Alexander Severus.* — More than a century had elapsed after the great fire of Titus, when Rome suffered again severely, in the reign of Commodus, from two fires, which laid waste a large part of the centre of the city. To the rebuilding of the monuments which had been wholly or in part destroyed, Septimius Severus and the other rulers of his house devoted much energy. Many magnificent new monuments also were erected by them, conspicuous among which were the palaces on the Palatine, the Septizonium, the *thermae* of Severus, and the *thermae* of Caracalla with the *aqua Antoniniana*.

The revival of building activity which found expression in these monuments was accompanied by certain important changes in the materials and methods of construction, which, though advantageous from the standpoint of utility, marked a decline in the beauty of the technique. The most striking of these changes are (1) the adoption of various kinds of tufa in place of bricks for the *caementa* in the body of the structures, with the use of pumice stone for the vaults, and (2) the introduction of facing bricks made of *bipedales*.

*Opus quadratum* was used very rarely and, except in a few monuments,<sup>2</sup> wholly for decorative purposes. For the structural parts of all classes of buildings, *opus caementicium* was almost universally used.

The *opus caementicium* varies little in type throughout the period. The *caementa* of the foundations and other massive parts of the structures are, where seen, of *selce*, except in the temple and atrium of Vesta,<sup>3</sup> where much broken and charred marble, travertine, and tufa appear, the refuse materials from the earlier buildings destroyed by the fire of 191 A.D. In the walls, the harder varieties of tufa are used frequently for

<sup>1</sup> It is probable that the monuments of Aurelian are to be excluded from this group. See p. 427.

<sup>2</sup> The most important of these is the arch of Severus in the Forum, the foundations of which are of *opus quadratum*.

<sup>3</sup> The atrium Vestae of this period is throughout of a very careless type of construction.

*caementa* in place of bricks. In the vaults, much pumice stone<sup>1</sup> appears, in addition to the yellowish gray tufa. The *caementa* in all parts of the buildings are noticeably smaller and less frequent than earlier. The mortar is a poorer variety of the red and white type of the preceding period. The *pozzolana-arena* is



FIGURE 7.—BRICK FACING OF THE TIME OF SEPTIMIUS SEVERUS.<sup>2</sup>

clean and very coarse, giving to the mortar its peculiar speckled appearance.<sup>3</sup> The predominating color is red, though reddish brown and gray appear also. The lime is clean, though less white than in the preceding period.

The facing bricks are made regularly of broken *bipedales* (Fig. 7). In the atrium Vestae, however, and in the upper part

<sup>1</sup> Good examples of the use of pumice stone are to be found in the thermae of Caracalla and in the upper corridors of the Colosseum.

<sup>2</sup> From the palace on the Palatine. Cf. the previous paper, p. 233, Fig. 1; p. 240, Fig. 6.

<sup>3</sup> See Fig. 7.

of the palace on the Palatine,<sup>1</sup> a considerable number of the earlier tile bricks are used, with a small amount of other older material. The shape of the bricks tends to approach the triangular form but the fronts only are sawed. They vary in

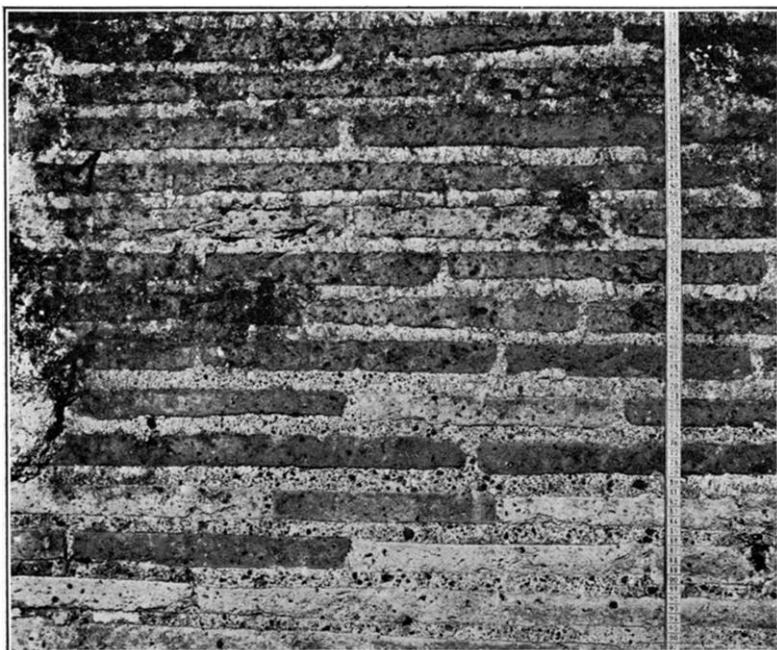


FIGURE 8. — FACING BRICKS OF THE TIME OF CARACALLA.<sup>2</sup>

width, in the monuments of Septimius Severus, from 2.3 cm. to 3 cm. The average width of 100<sup>3</sup> from the palace on the

<sup>1</sup> On account of the later restorations the original walls of the upper part of the palace are very hard to determine.

<sup>2</sup> From *thermae* of Caracalla.

<sup>3</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	1.8	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7
Number of bricks.	1	1	2	2	3	1	12	8	14
Measurement in centimetres.	2.8	2.9	3	3.1	3.2	3.3	3.5	3.7	3.8
Number of bricks.	8	5	24	4	4	4	4	1	2

Palatine and the restored portions of the arcus Neroniani is 2.8 cm., and the mean deviation .26 cm. In the monuments of the later rulers of the family, a heavier type of *bipedales* was used (Fig. 8); the facing bricks are, therefore, wider, varying normally from 2.9 cm. to 3.5 cm. The average width of 100<sup>1</sup> from the thermae of Caracalla is 3.2 cm. and the mean deviation .2 cm. Owing to the nature of the material, the length of the bricks varies greatly, but is usually from 25 cm. to 33 or 34 cm.<sup>2</sup>

Though these facing bricks resemble most nearly those made of roof-tiles, their composition is much less homogeneous, and the materials are coarser and less well mixed. Their texture is less fine, also, approaching at times that of the triangular bricks. They are, however, hard and carefully fired. Their color varies from the dark magenta of the roof-tile facing bricks to a yellowish magenta or magenta yellow. The mortar is of the same type as in the body of the walls, though at times a trifle finer. The horizontal joints are wide, increasing in proportion as the width of the bricks diminishes. They vary usually from .4 cm. to 2.5 cm., and the vertical joints from .5 cm. to 2 cm.

Bonding courses of the same type of *bipedales*<sup>3</sup> as those used for the facing bricks occur regularly in all the monuments.

A few of the walls near the caldarium in the thermae, and the lower part of a few of the remaining arches of the aqua Antoniniana are faced with bricks made from a heavier type of *bipedales*.<sup>4</sup> These bricks are from 3.5 cm. to 4.5 cm. wide, and from 20 cm. to 35 cm. long. They are coarse in composi-

<sup>1</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	2.2	2.3	2.5	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
Number of bricks.	3	1	1	1	1	4	23	13	14	15	9	9	1	4	1

<sup>2</sup> In 150 bricks, chosen in groups of 5 or 10, the length of 39 exceeds 31 cm., the limit of the length of triangular bricks. Cf. p. 406, n. 1.

<sup>3</sup> The bonding courses of the atrium Vestae are of the earlier yellow type.

<sup>4</sup> The presence of these bricks has led to some confusion concerning the date of this part of the thermae. The walls in which they are found are, however, of the same period as the rest of the building.



tion and of loose texture, but are usually well fired. Their color varies from yellow or pinkish yellow to light magenta.

The principal monuments or parts of monuments made of *opus caementicium* which belong to this time are the following:

Restored portions of the *arcus Neroniani* (201 A.D.).

Restored portions of the Pantheon: walls on the west side (202 A.D.).

The palace of Septimius Severus on the Palatine: the arches of the Belvedere and the upper rooms adjoining the stadium (*ca.* 203 A.D.).<sup>1</sup>

Restored portions of the Hippodromus on the Palatine (*ca.* 203 A.D.).

The temple of Vesta: the upper portion of the podium (early in the reign of Septimius Severus).

The atrium Vestae: the imperial atrium of the fifth period (early in the reign of Septimius Severus).<sup>2</sup>

The wall in the rear of the *templum Sacrae Urbis*.

The *thermae* of Caracalla (216 A.D.).

The *aqua Antoniniana*: arches behind the *thermae* of Caracalla (212-13 A.D.).

The *peribolus* of the *thermae* of Caracalla (built by Elagabalus and Alexander Severus).

The *aqua Alexandrina* (226 A.D.).<sup>3</sup>

Restored portions of the Colosseum: the substructures and a large part of the upper stories.

The restored arches of the *aqua Marcia* near the *porta Tiburtina*.<sup>4</sup>

The main characteristics by which the monuments of *opus caementicium* of this time may be distinguished from those of the earlier periods are: (1) The smallness of the size of the *caementa* in all parts of the structure, and the use for them of various varieties of tufa and of pumice stone, (2) the use of facing bricks made of *bipedales*, and (3) the decrease in the width of the bricks as well as the corresponding increase in the

<sup>1</sup> The work of Septimius Severus in this part of the Palatine is much less extensive than is usually held.

<sup>2</sup> Van Deman, *l.c.* p. 45 and Plan E.

<sup>3</sup> The data concerning the *aqua Alexandrina* are not as yet complete.

<sup>4</sup> The data concerning the restoration of the *aqua Marcia* are not as yet complete.

width of the mortar. No very noticeable differences exist between the monuments of this period and of the two periods immediately following.

*Aurelian.* — On account of the vast amount of the material to be considered, no final conclusions have as yet been reached concerning the materials and methods of construction used in the monuments of the time of Aurelian.<sup>1</sup>

*Diocletian.* — Of the monuments rebuilt or restored by Diocletian after the fire of 283 A.D., the curia alone displays indubitable evidence of his work. By rare good fortune, however, the great monument bearing his name, for which a whole district of the city was destroyed and upon which vast sums of money were expended,<sup>2</sup> is still in large part preserved. From this monument, with the curia, are derived the data upon which the conclusions here given are based.

While showing a rapid decline in technical finish and elegance, the *thermae*, and the *curia* in a lesser degree, are yet conspicuous in the maintenance of a certain uniformity in materials and methods entirely lacking in the great concrete structures of Maxentius, erected less than a decade later. The *thermae* and the *curia* are the last monuments also in which the materials, even of the external facing, belong in any considerable part to the time of the erection of the monument.

In general type, the *opus caementicium* of the body of the structures is not noticeably different from that of the earlier part of the century. The *caementa* of the walls<sup>3</sup> consist in large part of small pieces of brick of every variety laid in comparatively even rows. In the *thermae* are found also, at times, a considerable quantity of broken pieces of tufa and other stones, many of which show their earlier use in the walls of *opus reticulatum* of the republican and Augustan houses destroyed to give place for the baths.<sup>4</sup> The *caementa* of the vaults of the *thermae*<sup>5</sup> are of yellowish gray and light red

<sup>1</sup> The larger part of the existing remains of the Aurelian wall are the work of Aurelian, and not, as is generally held, of Honorius. The *thermae* of Caracalla were also extensively restored by him.

<sup>2</sup> C.I.L. VI, 1130 (= 31242): *Thermas . . . coemptis aedificiis pro tanti operis magnitudinae omni cultu perfectas Romanis suis dedicaverunt.*

<sup>3</sup> No foundations are visible.

<sup>4</sup> See above, n. 2.

<sup>5</sup> No vaults are visible in the curia.

tufa. The pieces are very small and are laid in horizontal rows held together by courses of *bipedales* inserted at regular intervals. The mortar differs little from that of the time of Severus and Caracalla, being a poorer variety of the white and red type.<sup>1</sup> While not so homogeneous as earlier, it is firm and

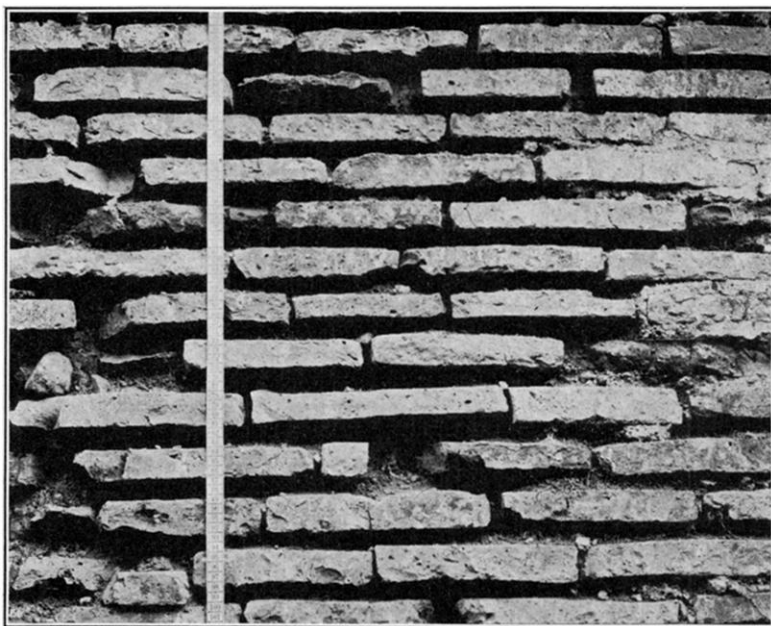


FIGURE 9.—BRICK FACING OF BIPEDALES OF THE TIME OF DIOCLETIAN.<sup>2</sup>

tenacious. The *pozzolana-arena* is coarsely sifted but clean. The color is more commonly red, though with a considerable mixture of brown and gray.

The walls are faced almost entirely with bricks made of *bipedales* of the period, similar to those which appear in the arches and bonding courses (Fig 9). Roof-tiles and bricks of other kinds appear occasionally. The width of the facing bricks, as of the *bipedales* from which they are made, is not uniform, varying usually from 3 cm. to 4 cm. The average width of

<sup>1</sup>The mortar is not so friable as that of the first century, which is called "dirty-white and red."

<sup>2</sup>From the *thermae* of Diocletian.

100<sup>1</sup> from the *thermae* and the *curia* is 3.5 cm., and the mean deviation is .4 cm. These facing bricks are usually shorter than those made of *bipedales* of the period of Severus and Caracalla, being usually but 20 cm. to 25 cm. long. In composition and texture also, they are inferior to the earlier type, resembling, at times, the badly puddled triangular bricks of the time of Nero. They are, however, as a rule, very hard and weather well. Their color varies from a deep almost brownish magenta to a magenta yellow. A few narrow bricks of a clear yellow tone appear, similar to those which are found in great numbers in the buildings of Aurelian. The mortar does not differ from that in the body of the structure. The horizontal joints are from 1.5 cm. to 3 cm. wide, in many cases exceeding 3.5 cm. The vertical joints show the same lack of uniformity, varying from .6 cm. to 3 cm.

Bonding courses of *bipedales*, similar to those from which the facing bricks are made, occur at regular intervals in all the walls.

The only monuments of *opus caementicium* of which remains exist are the *curia Julia* and the *thermae* of Diocletian.

Of the few marked characteristics which distinguish the monuments of *opus caementicium* of this period from those of the period of Severus and Caracalla, the most important are the irregularity in the size of the bricks and the increase in the width of the mortar joints. The monuments are easily distinguished from those of the following period by the comparative uniformity in the materials used, especially in the facing bricks.

## IX. THE PERIOD OF MIXED FACING BRICKS (MAXENTIUS—)

*Maxentius*. — In the midst of his struggle for supreme rule, Maxentius found time to plan a number of great monuments,

<sup>1</sup>The exact width of the bricks is as follows :

Measurement in centimetres.	2.3	2.4	2.6	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4
Number of bricks.	1	1	1	2	1	3	12	7	6	8	4

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Measurement in centimetres.	3.5	3.6	3.7	3.8	3.9	4	4.1	4.3	4.4	4.5	
Number of bricks.	23	3	2	5	2	12	1	1	1	4	

the greatest of which, however, the basilica and the temple of Romulus,<sup>1</sup> were left for his conqueror, Constantine, to finish. These two monuments, together with the circus of Maxentius and the temple of Venus and Rome, which was rebuilt by Maxentius, are still, in large part, preserved.

Of the comparative uniformity in materials and methods of construction which distinguish the work of Diocletian, but

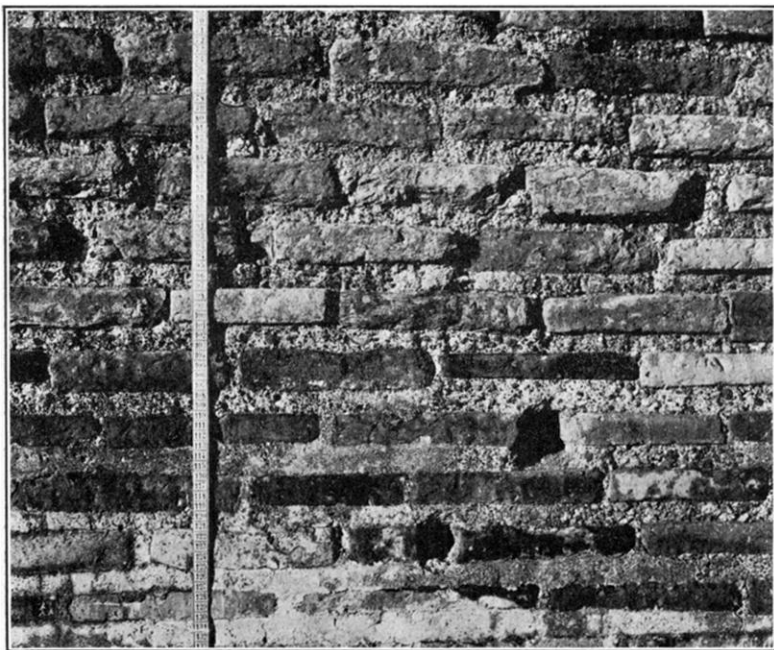


FIGURE 10. — BRICK FACING OF THE TIME OF MAXENTIUS.<sup>2</sup>

little trace is found in the conglomerate mass of broken materials of every period of which the monuments of Maxentius consist. For the *caementa* of the foundations, stones of every variety are used, with a smaller amount of brick. The pieces are not of uniform size and are laid with no attention to order. In the walls the *caementa* are, more commonly, of bricks of many kinds and of many periods laid in rough rows; in the

<sup>1</sup> It is possible that the temple was completed, though the name of Constantine was later attached to it.

<sup>2</sup> From the basilica of Constantine.

temple of Venus and Rome, however, very small *caementa* of tufa appear. For the vaults, bricks as well as tufa of several kinds are used. The mortar, by which the heterogeneous mass of materials is welded together, exceeds in amount that of the previous periods. It is irregular and coarse in composition, and less firm and hard than earlier. The color is not uniform, though red predominates. The lime is of medium good quality.

The facing, except in the circus of Maxentius, is composed of bricks of every type and period (Fig. 10). Among those which appear most conspicuously are the roof-tiles of the first and second centuries, the *bipedales* of the Severi and Diocletian, and, though more rarely, the triangular bricks of the first century. The courses of bricks show no regularity, being evened up by the wide layers of mortar. The average width of 100<sup>1</sup> bricks from the temple of Romulus, the basilica, and the temple of Venus and Rome, which are fairly typical, is 3.5 cm. and the mean deviation .6 cm. The length varies from a few centimetres to 35 or 40 cm. The horizontal mortar joints vary commonly from 1.5 cm. to 3.5 cm. and are often, especially below the bonding courses, 4 cm. or more.

Bonding courses, which are composed of *bipedales* of many widths, appear regularly.

In the circus of Maxentius, the facing is in large part of *opus mixtum*, the materials of which are wholly without uniformity.

The monuments or parts of monuments made of *opus caementicium* which may be assigned to this time are the following:

The temple of Venus and Rome: the entire superstructure (*ca.* 308 A.D.).

The temple of Romulus (finished by Constantine?).

The basilica of Constantine (finished by Constantine).

<sup>1</sup> The exact width of the bricks is as follows :

Measurement in centimetres.	2.1	2.3	2.5	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4
Number of bricks.	1	2	7	2	2	1	17	3	7	4	3
Measurement in centimetres.	3.5	3.6	3.7	3.8	4	4.1	4.2	4.3	4.5	4.7	5
Number of bricks.	10	2	2	3	13	4	6	1	6	1	3

*Constantine.* — In monuments of the time of Constantine, so far as it has yet been possible to classify them, the type of construction is identical with that of the monuments of Maxentius.

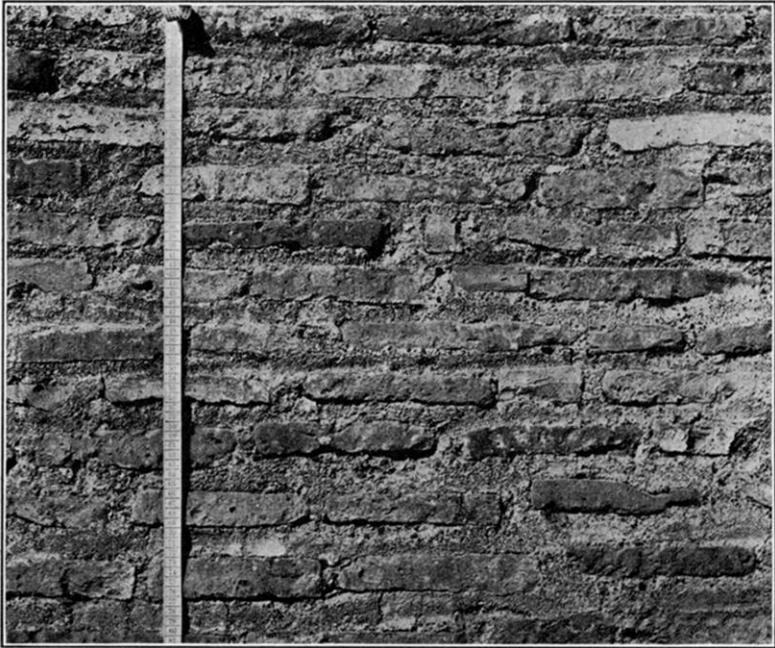


FIGURE 11.—BRICK FACING OF THE SEVENTH CENTURY.<sup>1</sup>

No classification of the monuments later than the period of Constantine has as yet been undertaken. The general type of the facing is shown in the illustration above.<sup>2</sup>

ESTHER BOISE VAN DEMAN.

ROME, JUNE, 1912.

<sup>1</sup> From the column of Phocas.

<sup>2</sup> Fig. 11.